Enhanced data-driven decision support for highly invasive vectors

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California Department of Public Health

- Marco Metzger, Vicki Kramer, Kerry Padgett

Centers for Disease Control and Prevention

- John-Paul Mutebi (Arboviral Diseases Branch)
- Roberto Barrera (Dengue Branch)

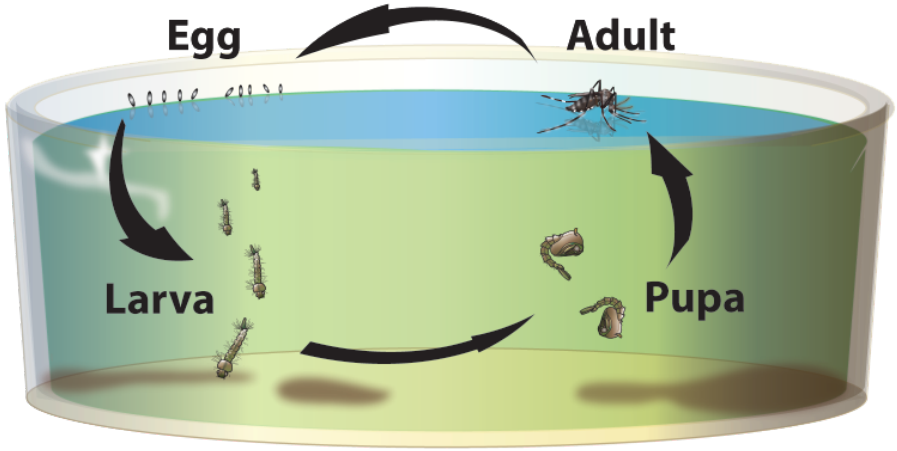
Invasive "Container-Breeding" *Aedes* Mosquitoes

Ae. albopictus
2011

Ae. aegypti
2013

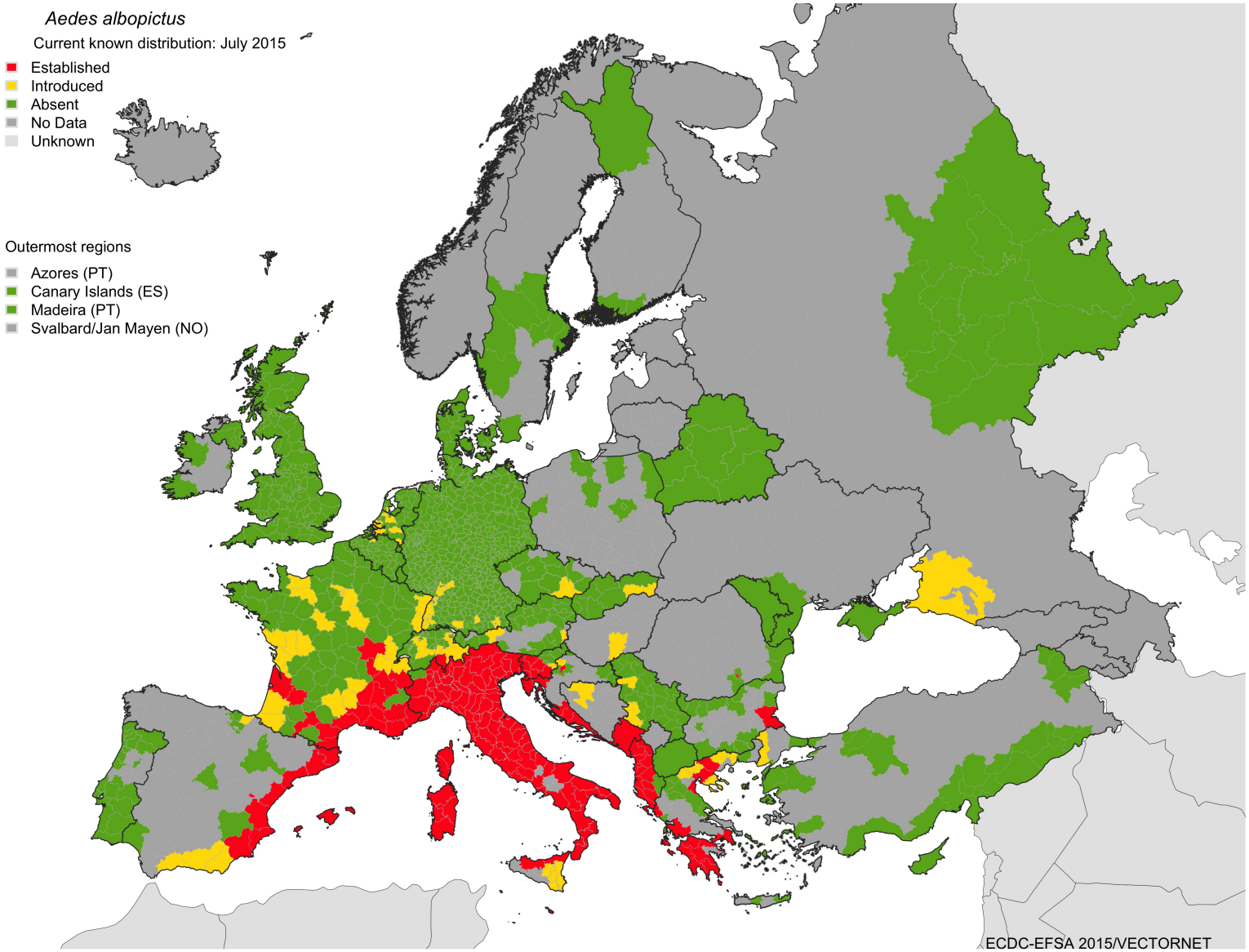
Ae. notoscriptus
2014

“Container-breeding” mosquitoes



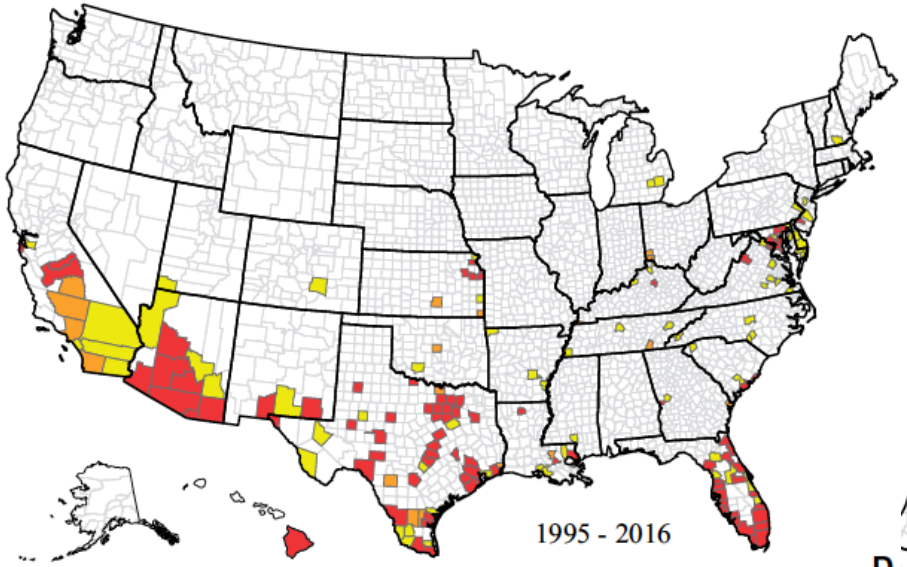
Sources: www.glacvcd.org; ECDC, Guidelines for the surveillance of native mosquitoes in Europe, 2014

Aedes albopictus spread in Europe



ECDC, Mosquito Maps

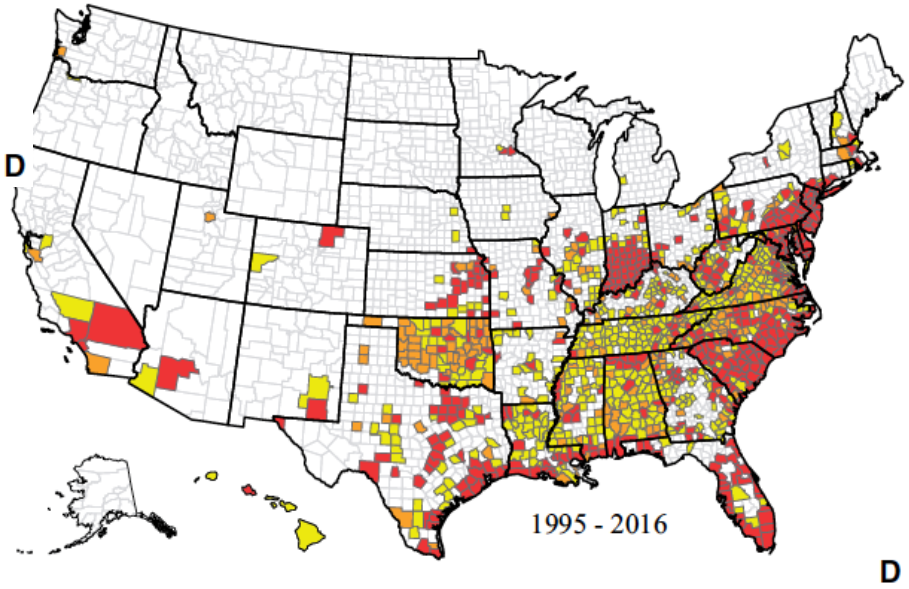
Aedes aegypti



Number of years with at least one mosquito reported

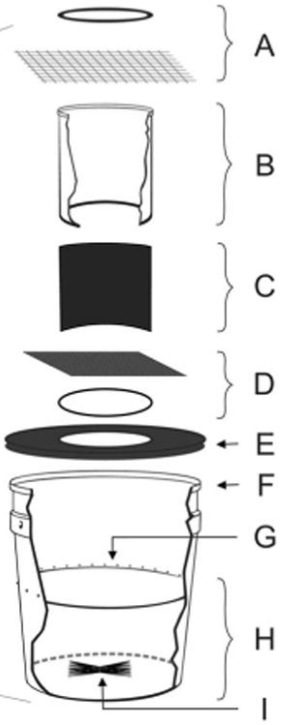
- No reported records
- 1 year
- 2 years
- 3 or more years

Aedes albopictus

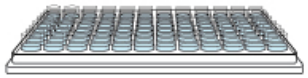


Tracking the spread of Zika virus vectors (*Aedes aegypti* and *Aedes albopictus*)

Egg-laying females



Surveillance for Zika virus and invasive mosquitoes



Homogenization
MagMAX™ Lysis/Binding Solution

RT-PCR to detect Zika virus in mosquitoes

MagMAX™ Sample Preparation System
MagMAX™ Express-96 Magnetic Particle Processor
MagMAX™-96 Viral RNA Isolation Kit

Real-Time RT-PCR
TaqMan® One-Step RT-PCR Kit
Applied Biosystems® 7900 HT
Fast Real-Time PCR System

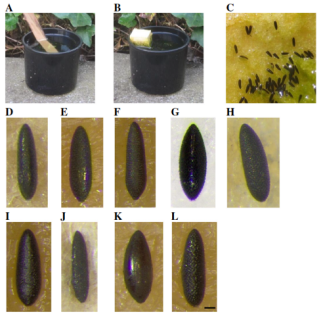
MVCAC

UCDAVIS
UNIVERSITY OF CALIFORNIA

DART
DAVIS ARBOVIRUS RESEARCH & TRAINING

CDPH
California Department Of PublicHealth

Viruses
- DENV
- CHIKV
- ZIKV
- WNV
- SLEV
- WEEV

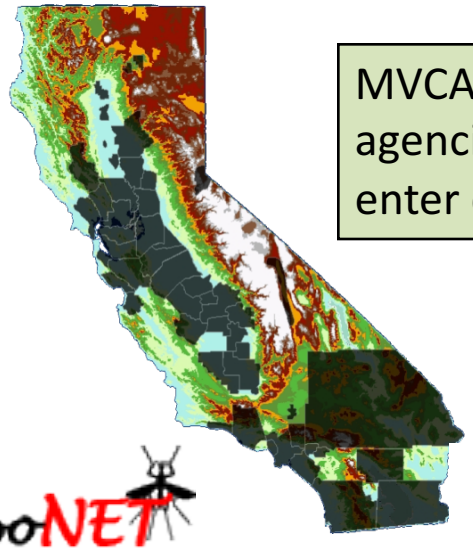


MALDI-TOF testing of Aedes eggs to identify species

Rapid Arbovirus Data Acquisition: CalSurv Gateway

Field data retrieved and laboratory test results entered

MVCAC agencies enter data



Central server

Results automatically sent to CDC

Historical Database updated

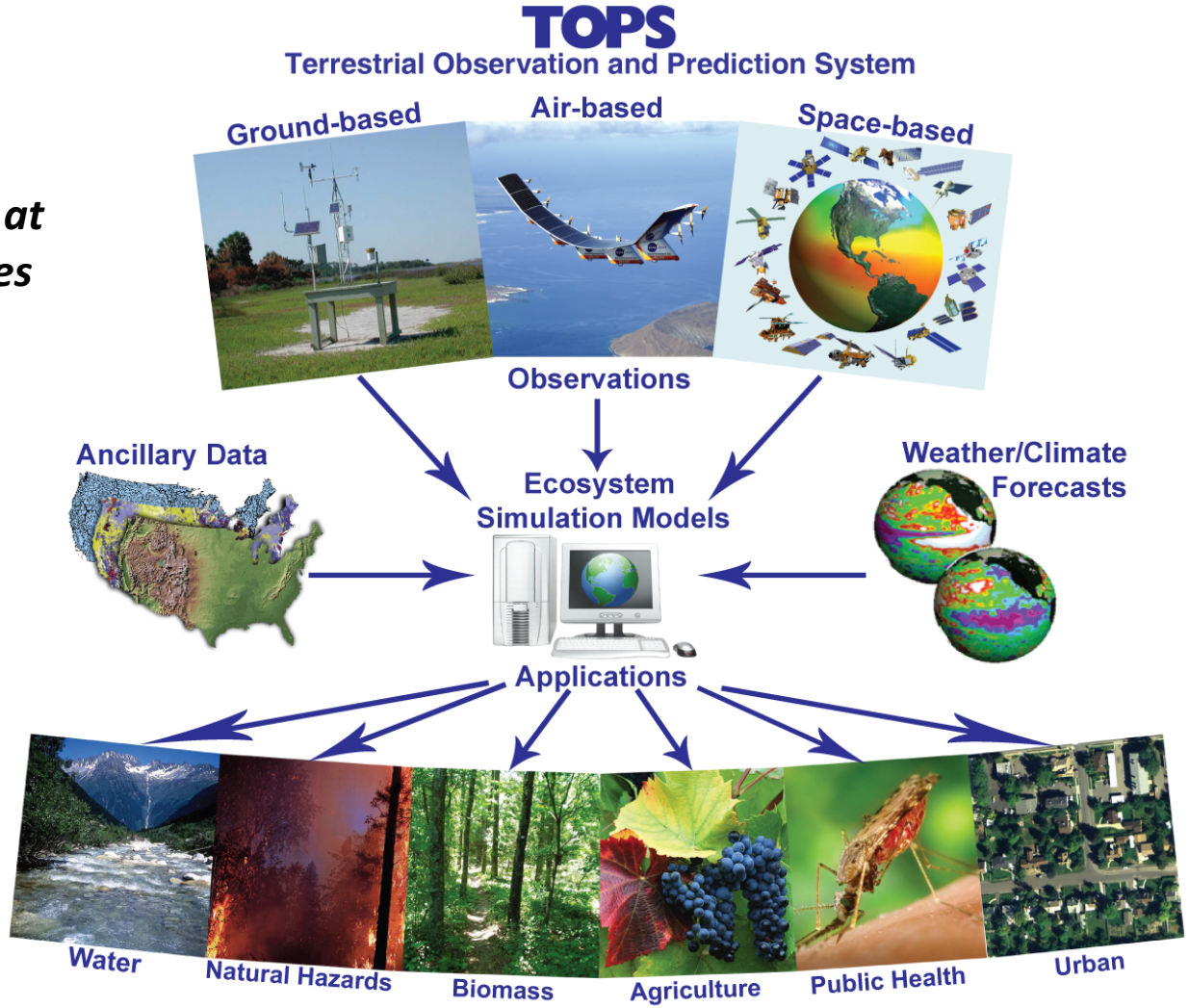
Arbovirus bulletins

Interactive maps automatically updated

Results e-mailed to client automatically after entry

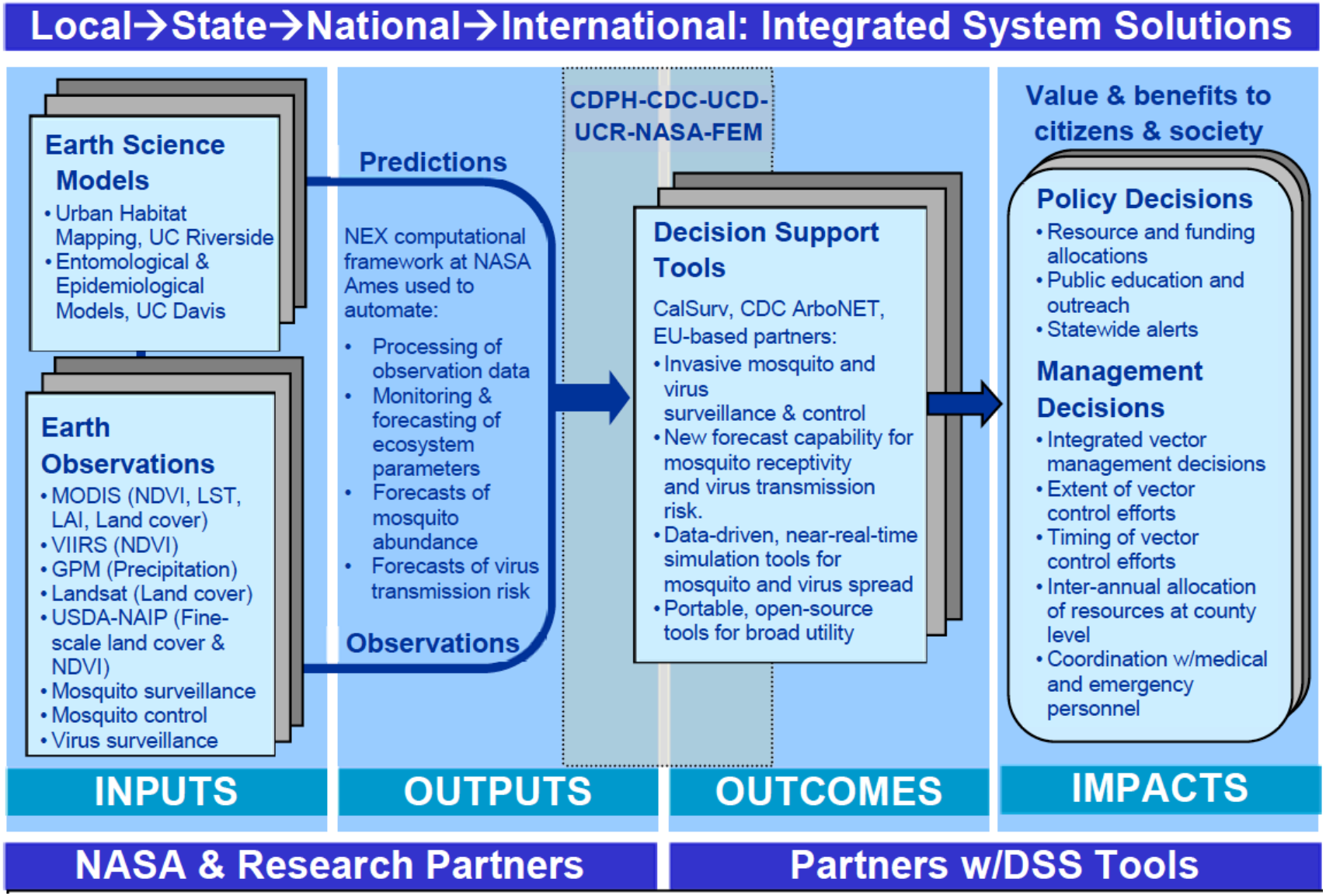
TOPS: Common Modeling Framework

Monitoring, modeling, & forecasting at multiple scales



Nemani et al., 2003 and 2007

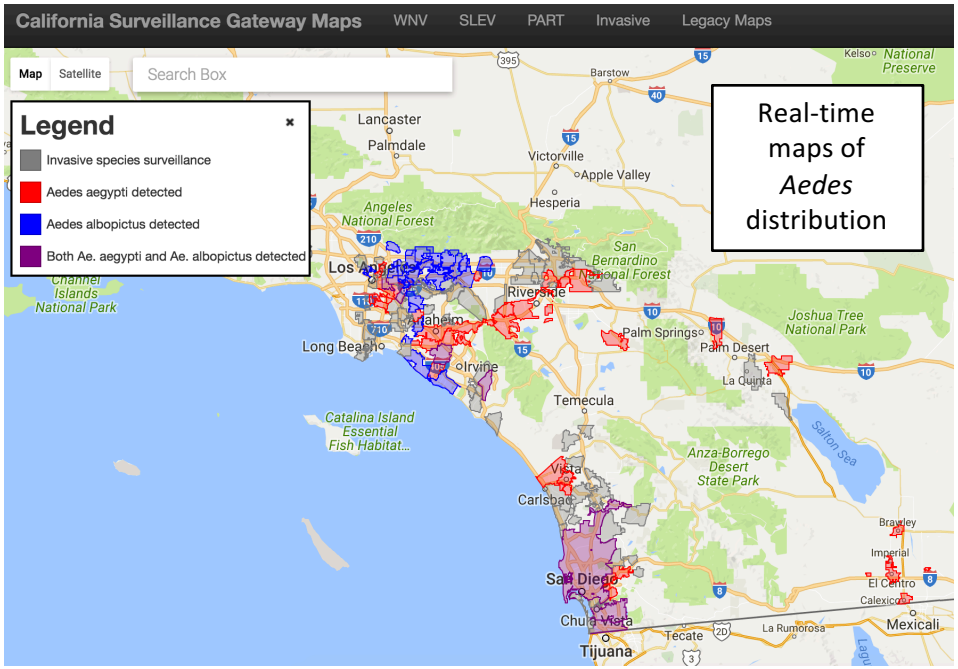
Project Milestones



Project Aims

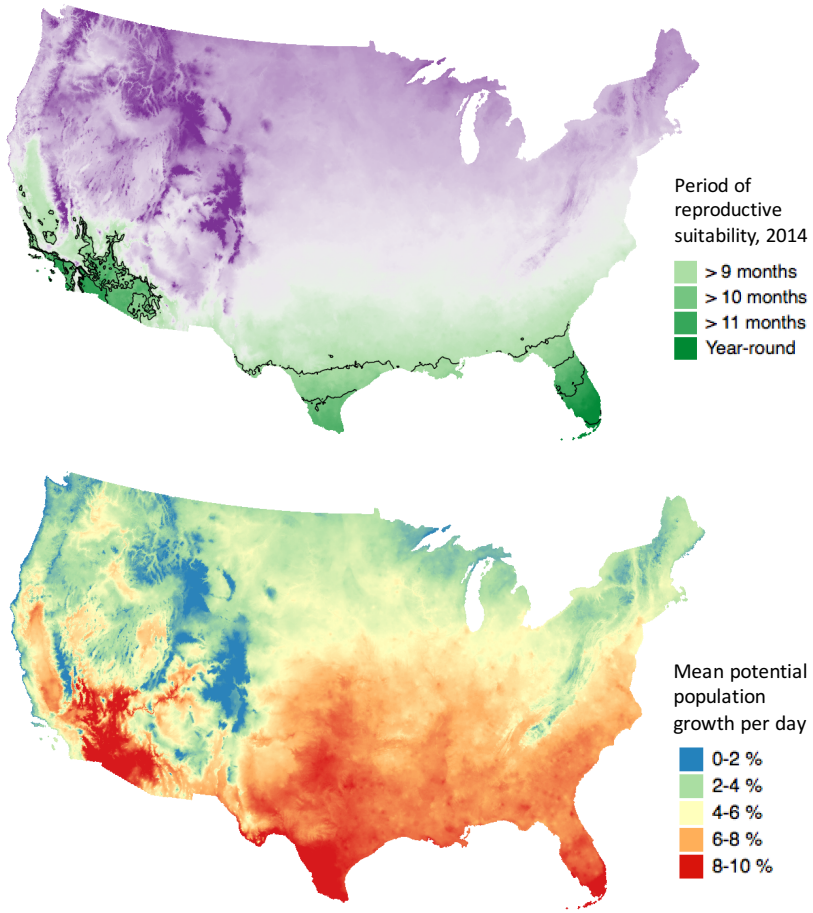
1. Develop distribution and suitability maps for Ae. albopictus and Ae. aegypti informed by near-real-time mosquito surveillance data and NASA and non-NASA earth observations.
2. Use maps derived from earth observations to drive generalizable stochastic models for mosquito dynamics and spread on real landscapes to guide surveillance and control.
3. Develop data-driven, dynamical dengue and chikungunya transmission models to predict human disease risk in space and time.
4. Link the risk maps and spread models to real-time surveillance data through integration into the existing CalSurv Gateway DSS.
5. Generalize models and DSS code for use by CDC and European partners.

Aim 1: Mapping Zika virus vectors



CalSurv California Vectorborne Disease Surveillance Gateway

CalSurv → http://maps.calsurv.org/invasive

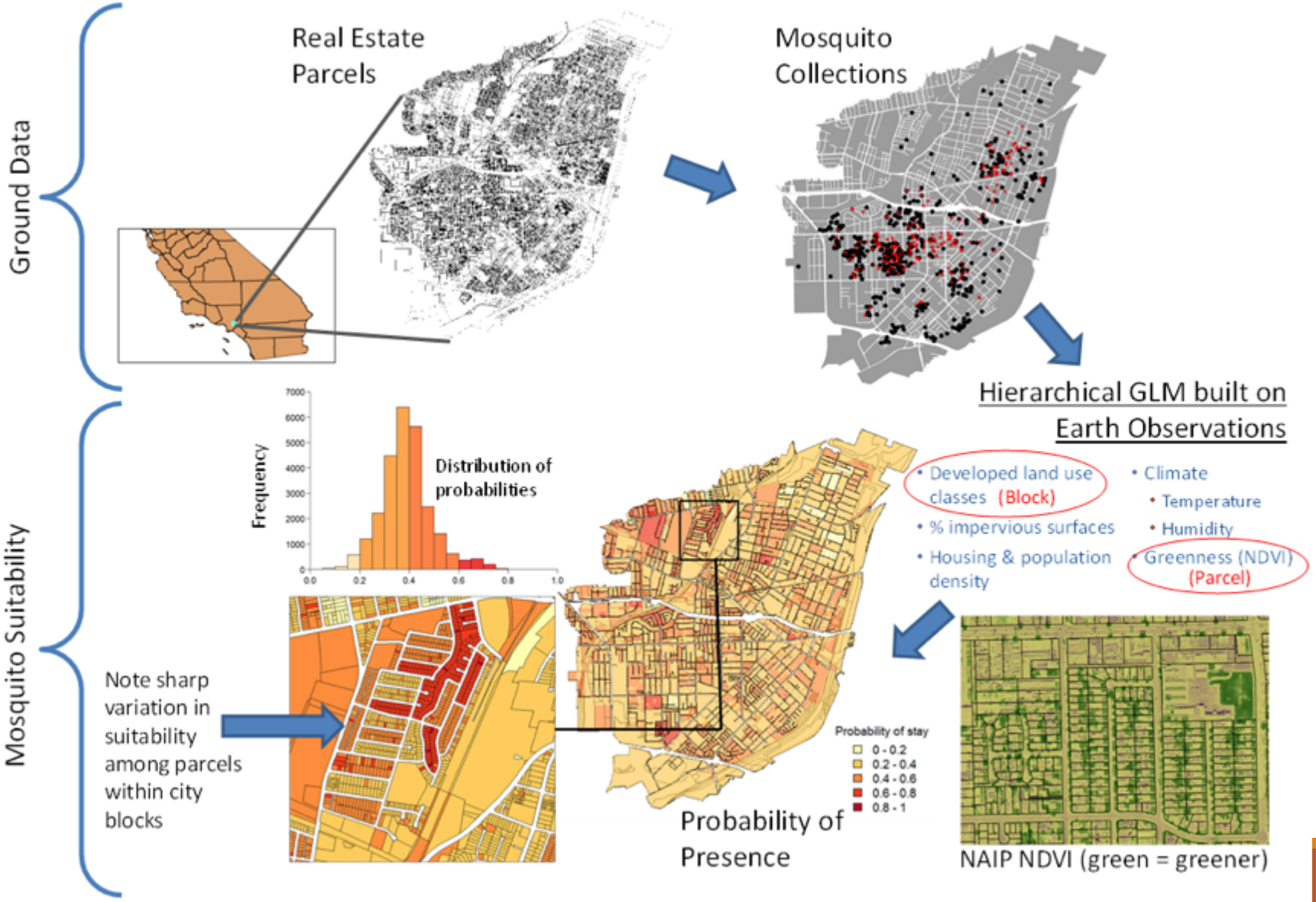


Climate-based suitability maps for Zika virus vectors
(M Donnelly, PhD Dissertation)

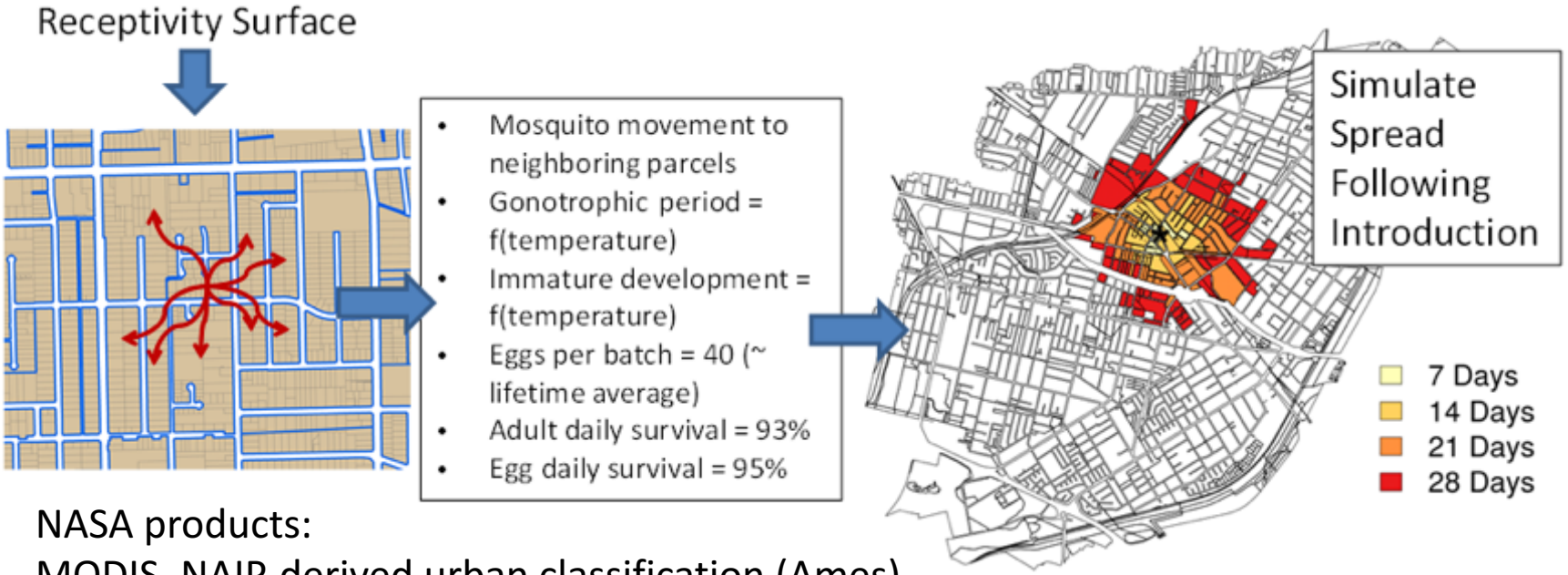
NASA products:
NEX Global Daily Downscaled Climate Projections

Donnelly MAP, Marcantonio M, Melton F, Barker CM. Seasonal reproductive rates for invasive *Aedes aegypti* and *Aedes albopictus* in the United States: past, present, and future. *(in prep)*

Aim 2: Data-Based Estimates for Suitability of Households



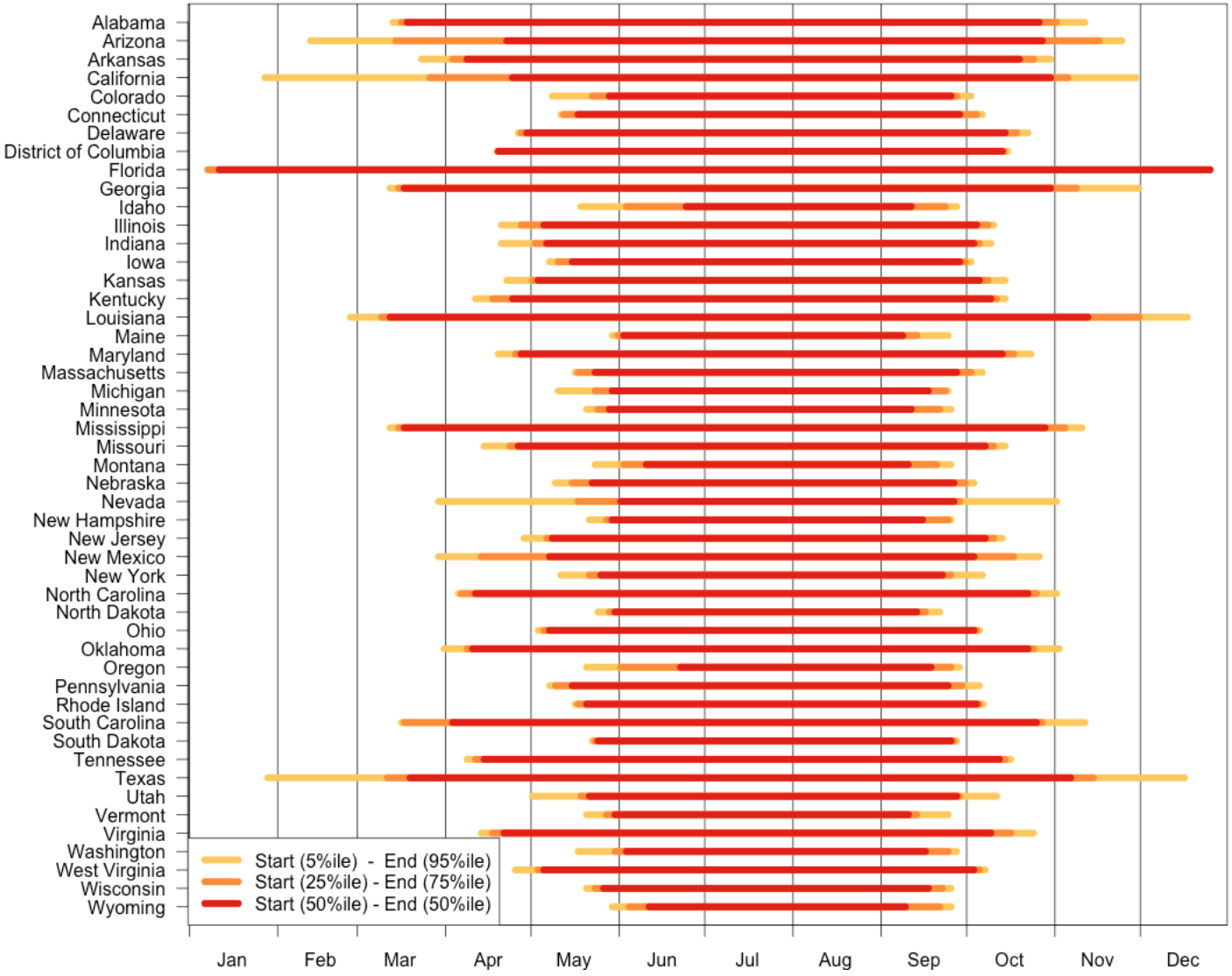
Aim 2: Simulations of *Aedes* spread



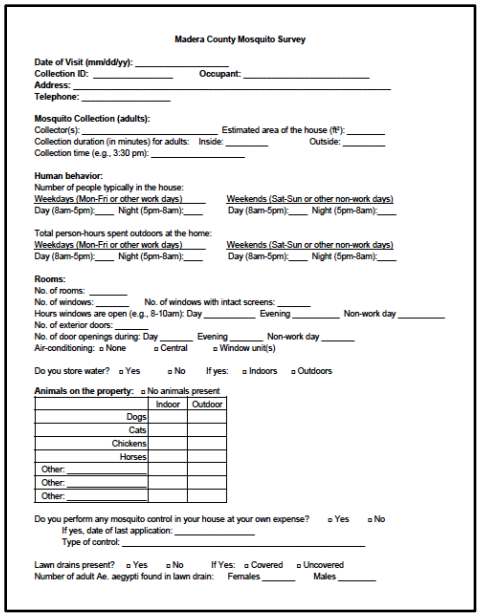
NASA products:
MODIS, NAIP-derived urban classification (Ames)

Montecino D, Marcantonio M, Perkins TA, Barker CM. **Modeling *Aedes albopictus* Skuse population dynamics and movement in urban landscapes**. *(in prep)*

Aim 3: Zika Risk: Length of the Ae. aegypti season in the U.S.



Aim 3: Risk for ZIKV outbreak in the U.S.?



Madera County Mosquito Survey

Date of Visit (mm/dd/yy): _____
Collection ID: _____ **Occupant:** _____
Address: _____
Telephone: _____

Mosquito Collection (adults):
Collector(s): _____ Estimated area of the house (ft²): _____
Collection duration (in minutes) for adults: Inside: _____ Outside: _____
Collection time (e.g., 3:30 pm): _____

Human behavior:
Number of people typically in the house:
Weekdays (Mon-Fri or other work days) ____ Weekends (Sat-Sun or other non-work days)
Day (8am-5pm):____ Night (5pm-8am):____ Day (8am-5pm):____ Night (5pm-8am):____

Total person-hours spent outdoors at the home:
Weekdays (Mon-Fri or other work days) ____ Weekends (Sat-Sun or other non-work days)
Day (8am-5pm):____ Night (5pm-8am):____ Day (8am-5pm):____ Night (5pm-8am):____

Rooms:
No. of rooms: _____
No. of windows: _____ No. of windows with intact screens: _____
Hours windows are open (e.g., 8-10am): Day _____ Evening _____ Non-work day _____
No. of exterior doors: _____
No. of door openings during: Day _____ Evening _____ Non-work day _____
Air-conditioning: ¤ None ¤ Central ¤ Window unit(s)

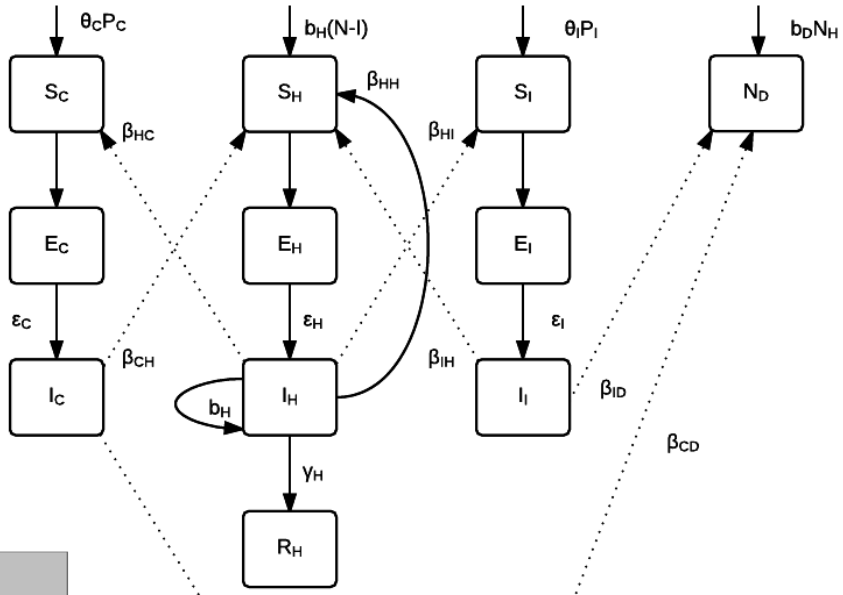
Do you store water? ¤ Yes ¤ No If yes: ¤ Indoors ¤ Outdoors

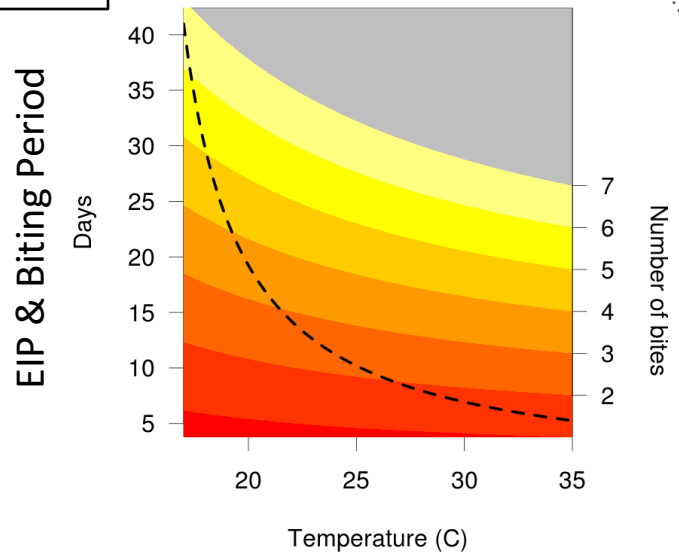
Animals on the property: ¤ No animals present

	Indoor	Outdoor
Dogs		
Cats		
Chickens		
Horses		
Other: _____		
Other: _____		
Other: _____		

Do you perform any mosquito control in your house at your own expense? ¤ Yes ¤ No
If yes, date of last application: _____
Type of control: _____

Lawn drains present? ¤ Yes ¤ No If Yes: ¤ Covered ¤ Uncovered
Number of adult Ae. aegypti found in lawn drain: Females _____ Males _____





Next Steps (Yr 1.5-2.5)

Mechanistic Models

Models for Ae. albopictus and Ae. aegypti spread

- Use models to define efficient surveillance and control strategies
- Characterize effect of urban landscape structure on spread rates and establishment

Biologically-based suitability surfaces for surveillance decision support

Microhabitat temperatures (vs. MODIS)

Modeling the observational process

Mapping for multiple data streams (NASA products: MODIS, GPM)

Outbreak risk for Zika, dengue, and chikungunya viruses

U.S. (CDC & other collaborators) → California (CDPH, MVCAC)

Budget, Years 1-2 (Mar 1, 2015 – Feb 29, 2017)

UC Davis: $778,441 (incl. $107,526 Zika supplement)

Direct award to NASA Ames: $122,026

- Expenses through Aug 2016: $374,774
- Committed: $260,061
- Unallocated: $143,606

Changes:

- Reiner move Indiana Univ to Univ of Washington
- Add students Olivia Winokur, Courtney Shelley
- Hiring post-doc for lab work to param. Zika models

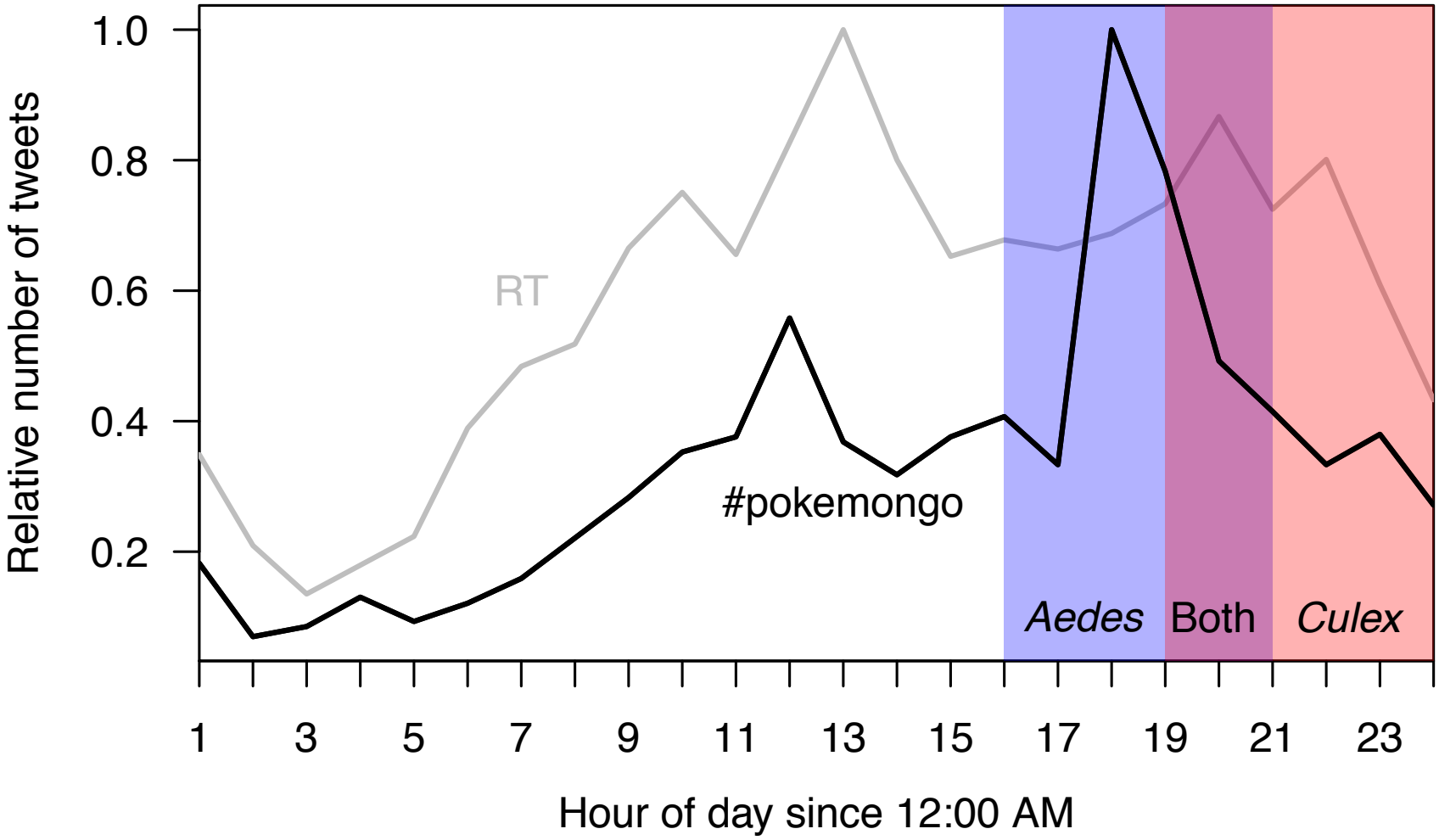
Risk:

- Data contributions from stakeholders
- Mitigate with regular reports on data gaps

Milestones & ARL Targets

Current ARL = 5
(Aug 2016)

Task	Qtr→	Year 1				Year 2				Year 3			
		1	2	3	4	1	2	3	4	1	2	3	4
Initial Survey on CalSurv DSS Needs		**X**	**X**										
Aim 1: Map *Aedes* distribution and receptivity		X	X	**P**	X	X	**P**						
Aim 2: Map potential for *Ae. albopictus* & *Ae. aegypti* invasion & spread				X	X	X	**P**	X	X	**P**			
Aim 3: Develop DENV/CHIKV transmission models to estimate outbreak risk						X	X	X	**P**	X	X	**P**	
Aim 4: Implement tools in CalSurv DSS		Numbers below represent ARL targets											
A. *Aedes* distribution mapping				**3**	4	5	6	7	8	**9**			
B. *Aedes* spread simulator						**3**	4	5	6	7	**8**		
C. DENV/CHIK outbreak simulator								**3**	4	5	6	7	**8**
Aim 5: Generalize maps for US and S Europe													
D. *Aedes* distribution mapping						**3**	4	5	6	7	8	**9**	



Oidtman RJ, Christofferson RC, ten Bosch Q, Espana G, Kraemer MUG, Tatem AJ, Barker CM, Perkins TA. (resubmitted after revision) Pokémon Go and exposure to mosquito-borne diseases: how not to catch 'em all *PLoS Currents Outbreaks*